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(71) Applicant(s)
Cetsa Limited

(Incorporated in Ireland)

Heritage House, 23 St Stephen's Green, Dublin 2, Ireland

(72) Inventor(s)
Francis Joseph Anderson

(74) Agent and/or Address for Service
Mewburn Ellis
York House, 23 Kingsway, LONDON, WC2B 6HP, United Kingdom

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(54) An electrical circuit for use in a security system

(57) A security circuit (1) comprises a plurality of sensor units (2,3 and 4) connected by A and B wires which form a loop circuit (6) through an end of line resistor (R1) to a main control circuit (10). All the sensor units (2,3 and 4) comprise a tamper indicating switch (12) for indicating tampering with a housing (11) of the switches (2,3 and 4). The sensor units (2) comprise reed switches (14) which are bridged by resistors (R2) of similar value but of value different to the end of line resistor (R1). The sensor units (3) comprise inertia switches (15) and the sensor unit (4) comprises a panic switch (16) which is bridged by a resistor (R3) of resistance value of which is different to the resistors (R1) and (R2). When the switches (12,14,15 and 16) are closed, the impedance of the loop circuit (6) is equal to the value of the resistor (R1). On any one or more of the reed switches (14) and/or the panic switch (16) or a tamper switch (12) opening, the impedance of the circuit changes, so that the type of switch which has changed state can be determined by the monitoring circuit (10). By monitoring the mark space ratio of a DC signal applied to the loop circuit (6), a determination can be made of an inertia switch (15) vibrating.

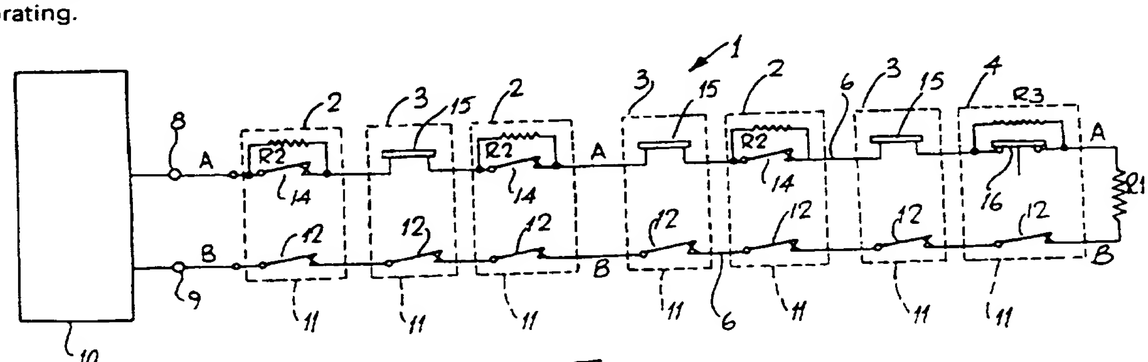

Fig.1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

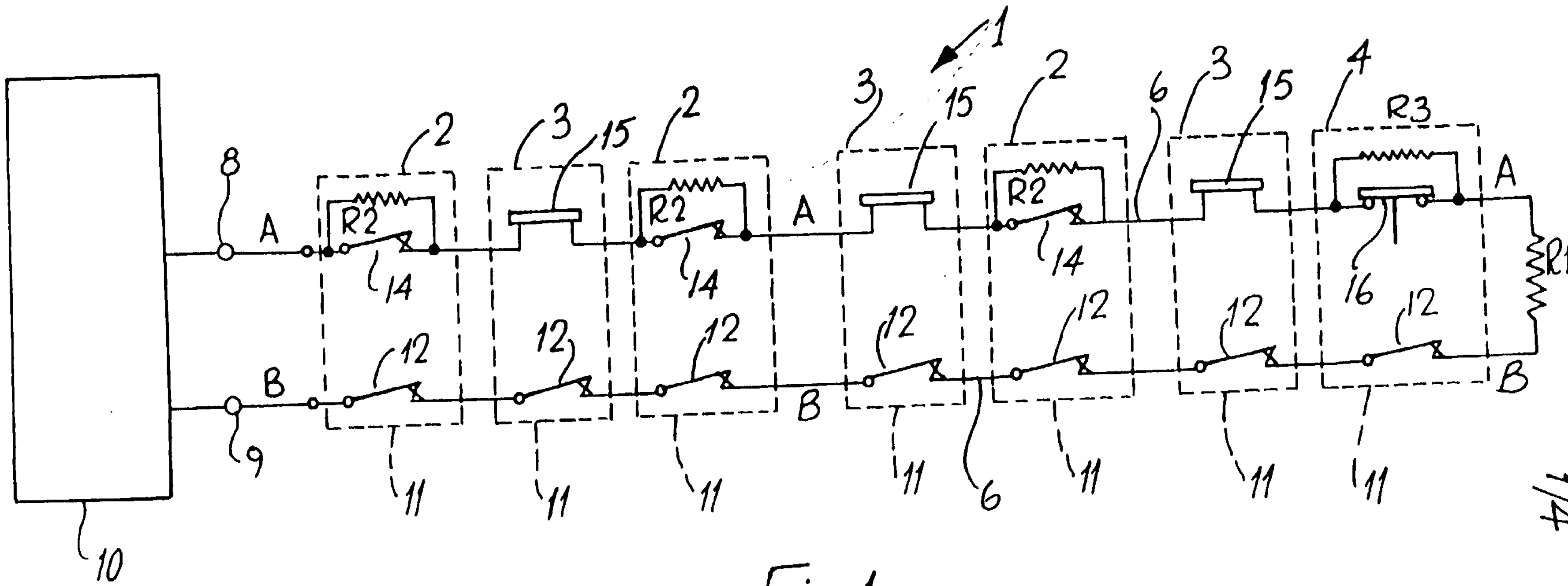

Fig.1

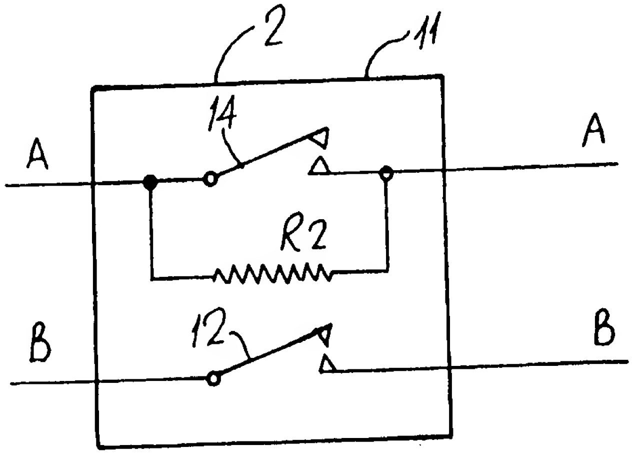

Fig.2

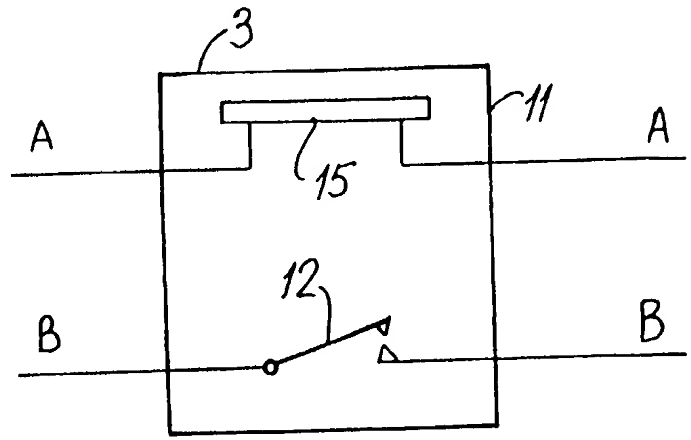

Fig.3

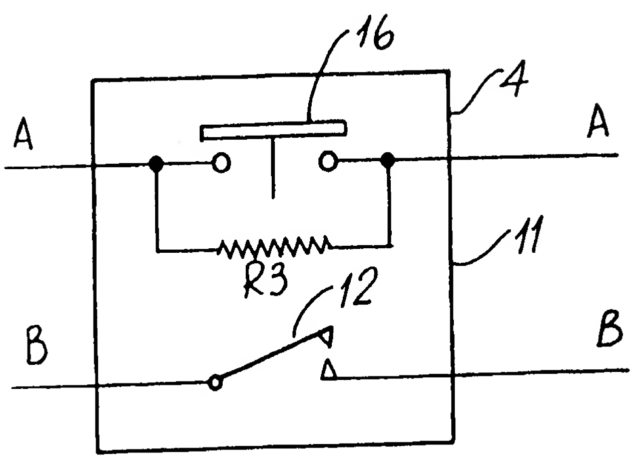

Fig.4

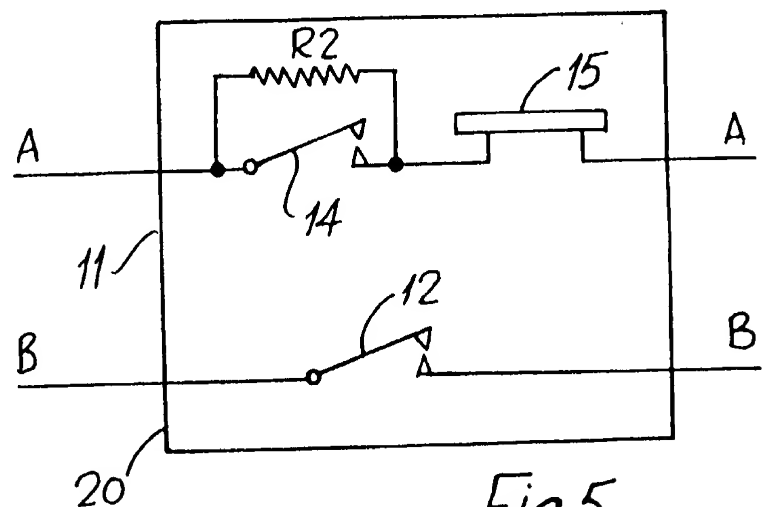

Fig.5

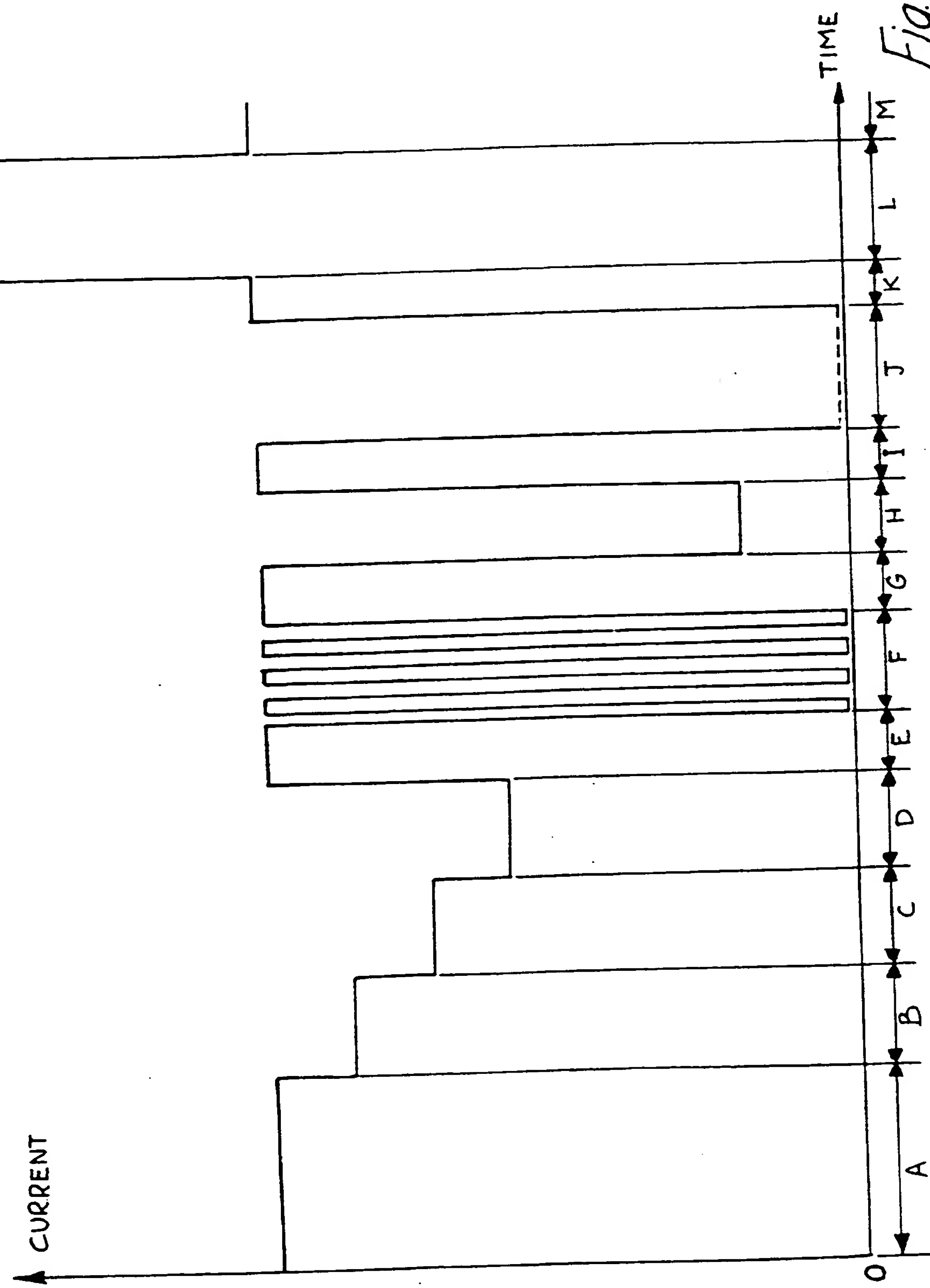

Fig.6

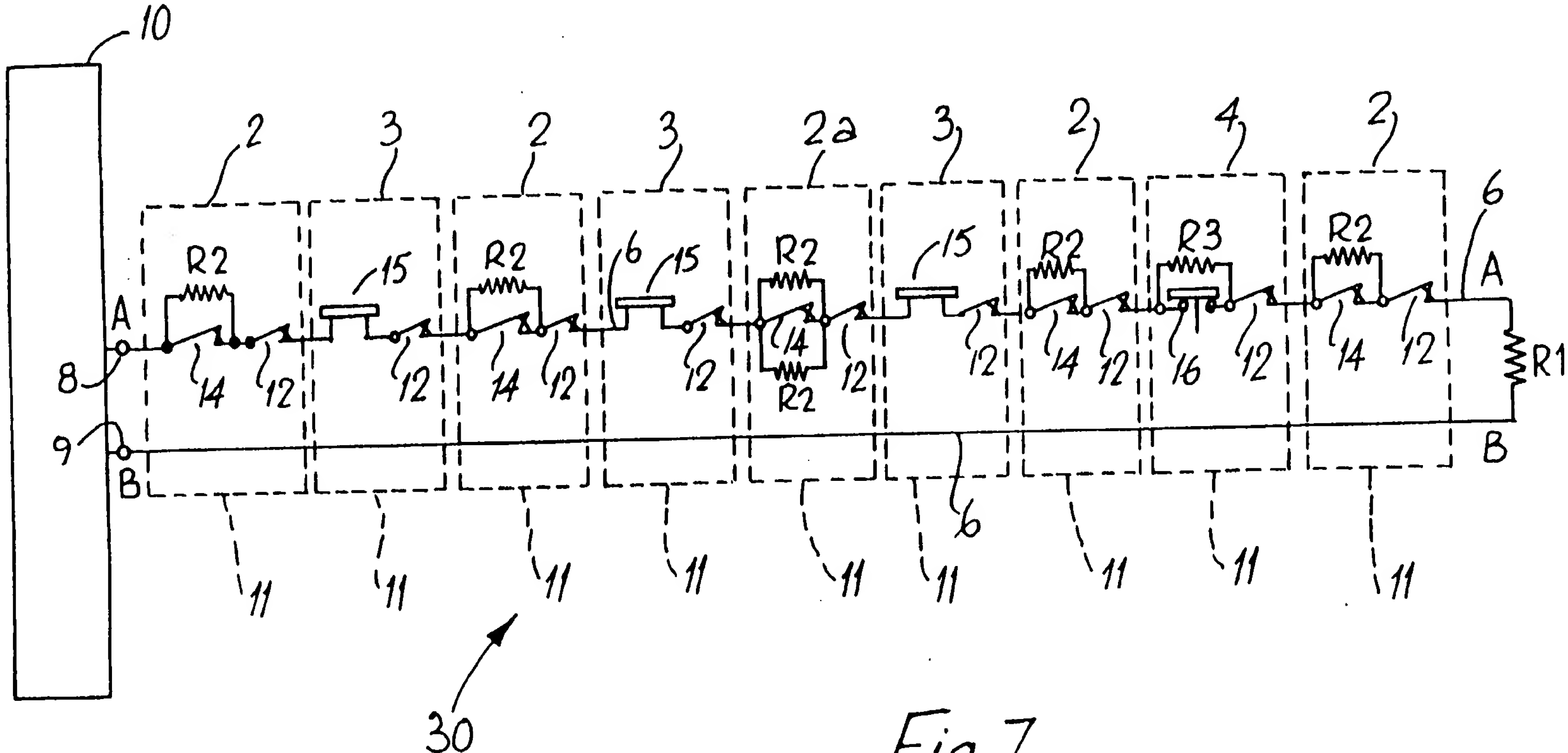
10
2
3
2
3
2a
3
2
4
2
R2
15
R2
6
15
R2
14
R2
15
R2
R3
R2
A
A
6
8
9
B
14
12
12
14
12
12
12
12
14
12
16
12
14
12
R1
B
6
11
11
11
11
11
11
11
11
11
30

Fig. 7

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"An electrical circuit"

The invention relates to an electrical circuit comprising a plurality of bi-state devices of different types, in which the identity of a bi-state device which has changed state may be determined by type of device.

Electrical security intruder detection circuits, in general, comprise a plurality of bi-state devices for securing to windows, doors, and the like of a building for detecting an attempt to gain access to a building. Additionally, such security circuits may comprise one or more bi-state devices of the type commonly referred to as a panic switch, in other words, a button operated bi-state switch which may be activated in the event of an emergency. Bi-state devices which are normally mounted on windows and doors, may be broadly categorised as being one of two types, typically, a mono-stable device which is only stable in one state, and a bi-stable device which is stable in two states for so long as it is held in the respective states.

Mono-stable devices, in general, are used for detecting vibrations or a shock caused by a sudden impact, and typically, are provided by inertia switches. Such inertia switches, in general, comprise an electrically conductive inertia mass which is supported on two or

more spaced apart electrically insulated, electrically conductive supports in stable equilibrium. The inertia mass closes an electrical circuit between the supports. On the inertia switch being subjected to an impact or vibrations, the inertia mass commences to lift off the supports and vibrate thereby opening and closing a circuit between the support pins at a frequency similar to the frequency of vibration of the inertia mass. Such inertia switches and other vibration sensing devices in which an inertia mass is supported on two or more supports and vibrates thereon are thus, stable in a closed circuit state and are unstable in an open circuit state, and hereinafter are referred to as mono-stable devices.

Bi-stable devices are typically, for example, a magnetic reed switch, a button operated panic switch and a tamper indicating switch of the type which would be mounted in a housing of a sensor unit for indicating tampering with the housing. While such devices are not necessarily stable in both states, namely, an open and a closed state, in that when operated from one state to the other, they may only stay in that other state for so long as they are held in the said other state, they are none the less stable in both states for so long as they are held in at least one of the two states, unlike inertia switches which are entirely unstable in an open

circuit state. For example, a button operated panic switch is stable in the closed state, and remains stable in the open state for so long as the switch is held open by the button. However, on release of the button the switch returns to the closed state, generally, under spring action. For convenience all such bi-state switches are referred to hereinafter as bi-stable switches. In the case of a magnetic reed switch, which as well as a tamper indicating switch is also included hereinafter in the term bi-stable switch, the reed switch is held in the closed state by a magnet which is located in close proximity to the reed switch. Typically, the magnet may be mounted on a door or window, while the reed switch is mounted on a frame of the door or window. On the reed switch being moved out of the magnetic field range of the magnet by opening a door or window, the reed switch changes state and goes into an open circuit state.

In general, where an alarm condition occurs at a bi-state device, it is important to be able to identify by type the bi-state device at which the alarm condition occurred. In general, it is not essential that the actual bi-state device be identified, but it is important that an identification of the type of bi-state device can be made. It is also desirable that it should be possible to inhibit all the bi-state devices

of each particular type independently of the bi-state devices of the other types.

In the known art, to achieve this, and to enable identification by type of a bi-state device at which an alarm condition occurs, it is necessary to provide separate circuits for the bi-state devices of each different type. These separate circuits are then connected to different zones of a main control circuit which monitors the state of the respective circuits. The fact that separate circuits are required for the devices of each particular type leads to relatively complicated circuitry, and also requires significant additional wiring.

This is a particular problem where it is desired to provide two and in many cases three bi-state devices in a single sensor unit, such as a bi-stable device, for example, a reed switch, a mono-stable device, for example, an inertia switch and a second bi-stable device, for example, a tamper indicating switch to indicate tampering with the sensor unit, In such cases, in general, it is necessary to provide a cable with six wires for connecting such a single sensor unit to the main control circuit. Two of the wires of the six wire cable are required for the reed switch, which is wired to one zone of the main control circuit, two

more of the wires in the six wire cable are required for the inertia switch, which is wired to a different zone of the main control circuit, and the last two wires of the six wire cable are required for connecting the tamper switch to a third zone of the main control circuit.

All the reed switches of the sensor units which comprise reed switches are connected to the two wires which are connected to the zone for the reed switches. All the inertia switches of the sensor units which have inertia switches are connected to the two wires which are connected to the zone for inertia switches, and all the tamper switches of the sensor units are wired to the two wires which are connected to the zone for tamper switches.

The main control circuit monitors the zones separately, and thus, the zone in which an alarm condition occurs can be readily identified, and thus the type of device which has been subjected to the alarm condition can be readily determined. Additionally, since the bi-state devices of different types are wired separately to the respective zones of the main control circuit, any one or more of the zones can be inhibited independently of the other zone or zones, and thus, bi-state devices of different types may be inhibited independently by type.

There is therefore a need for an electrical circuit which comprises a plurality of bi-state devices of different types in which the identity of a bi-state device which has changed state may be determined by type of device, and which preferably, requires only two wires for connecting all the bi-state devices to a main control circuit.

The present invention is directed towards providing such an electrical circuit.

According to the invention there is provided an electrical circuit comprising a plurality of bi-state devices, each having a closed circuit state and an open circuit state, the bi-state devices being connected in series in a loop extending between two input terminals, at least one of the bi-state devices being a mono-stable device of the type hereinbefore defined, and a plurality of the bi-state devices being bi-stable devices of the type hereinbefore defined, there being provided at least one of each of N types of bi-stable devices, where N is an integer greater than zero, each of the bi-stable devices of at least N-1 types having an associated impedance element, the associated impedance elements being arranged with their corresponding bi-stable devices so that irrespective of the state of the bi-stable devices which include an

associated impedance element, electrical continuity is maintained through the loop while the bi-stable devices without an associated impedance element and the mono-stable devices are in a closed circuit state, the associated impedance elements of the bi-stable devices which are of the same type each having the same impedance value, and the impedance value of the associated impedance elements of bi-stable devices of different types being different, so that the loop circuit has a predetermined value of impedance across the input terminals when all the said bi-state devices are in a normal state, and a value of impedance different from the said predetermined value when one of the bi-state devices is caused to change state for enabling the type of bi-state device which has changed state to be identified.

In one aspect of the invention each associated impedance element is connected in parallel with its corresponding bi-stable device.

Preferably, each associated impedance element comprises a resistor.

Advantageously, the values of the associated impedance elements are selected so that when more than one bi-state device changes state the type or types of bi-

state devices which have changed state can be identified from the impedance value of the loop circuit.

In another aspect of the invention a main impedance element is connected in the loop circuit in series with the bi-state devices so that should the main impedance element be shunted out of the loop circuit by short circuiting the loop circuit by connecting any portion of the loop between one of the input terminals and the main impedance element with any portion of the loop between the other input terminal and the main impedance element, the impedance of the loop circuit across the input terminals changes for enabling detection of the short circuit.

In a further aspect of the invention the loop circuit comprises two legs, namely, an outgoing leg and a return leg, one end of the outgoing leg being connected to one of the input terminals, and one end of the return leg being connected to the other of the input terminals, the other ends of the respective outgoing and return legs being connected to the main impedance element.

In one aspect of the invention the bi-stable devices with the associated impedance elements and the mono-

stable devices are connected in series in one of the said outgoing and return legs, and the bi-stable devices without an associated impedance element are connected in series in the other of the outgoing and return legs of the loop circuit.

Preferably, the main impedance element is a resistor.

In general, each bi-stable device comprises a switch.

In one aspect of the invention each bi-stable device of one type may comprise a magnetic reed switch. Each bi-state device of another type may comprise a button operated panic switch. Each bi-state device of a further type may comprise a tamper indicating switch associated with a housing of a sensor unit which comprises at least one of two or more different bi-state devices.

In one aspect of the invention each magnetic reed switch may be provided with one of the associated impedance elements, and each button operated panic switch may be provided with one of the associated impedance elements.

In another aspect of the invention at least of the mono-stable devices may comprise a vibration sensing

device, and at least one of the mono-stable devices may comprise a shock sensing device. Additionally, or alternatively at least one of the mono-stable devices may comprise an inertia switch. In general, each mono-stable device is stable in the closed circuit state.

In another aspect of the invention the electrical circuit further comprises a main control circuit connected to the input terminals of the loop circuit for monitoring the impedance of the loop circuit across the two input terminals for determining if and which type of bi-state device has changed state.

Preferably, the main control circuit comprises a means for comparing the impedance value of the loop circuit with a plurality of reference impedance values for determining the type or types of bi-state devices which have changed state.

Advantageously, the main control circuit comprises a means for applying a voltage across the input terminals of the loop circuit, and the comparing means comprises a means for monitoring the current flowing through the loop circuit for determining the impedance value of the loop circuit.

In one aspect of the invention the comparing means

comprises a means for detecting the mark space ratio of the current flowing through the loop circuit for determining the mark space ratio of a graph of the current for determining the frequency of change of the current for determining the type of bi-state device which has changed state. Preferably, the comparing means compares the mark space ratio of the current signal flowing through the loop circuit with a reference mark space ratio for determining if a mono-stable device has changed state.

In one embodiment of the invention the electrical circuit is a security intruder detection circuit.

Additionally, the invention provides a sensor unit for use in the electrical circuit according to the invention, the sensor unit comprising a housing, and at least two bi-state devices located in the housing, and arranged for connecting into the loop circuit in series, one of the bi-state devices being a tamper indicating means for indicating tampering with the housing, and the other of the bi-state devices being a bi-stable device, and an associated impedance element being associated with the bi-stable device.

In one aspect of the invention the bi-stable device is a magnetic reed switch.

Preferably, the tamper indicating means is a bi-stable switch, the state of the bi-stable switch being responsive to tampering with the housing. Ideally, both of the bi-stable devices are normally closed.

In one aspect of the invention the associated impedance element is a resistor.

Further the invention provides a kit of parts for forming the electrical circuit according to the invention.

The invention will be more clearly understood from the following description of some preferred embodiments thereof which are given by way of example only, with reference to the accompany drawings, in which:

Fig. 1 is a circuit diagram of an electrical security intruder detection circuit according to the invention,

Fig. 2 is a circuit diagram of a bi-state device of the circuit of Fig. 1,

Fig. 3 is a circuit diagram of another bi-state device of the circuit of Fig. 1,

Fig. 4 is a circuit diagram of another bi-state device of the circuit of Fig. 1,

Fig. 5 is a circuit diagram of a further bi-state device which may be connected into the circuit of Fig. 1,

Fig. 6 is a graphical representation of different types of signals which may be detected in the electrical circuit of Fig. 1 under different conditions prevailing in the circuit, and

Fig. 7 is a circuit diagram of an electrical security intruder detection circuit according to another embodiment of the invention.

Referring to the drawing and initially to Figs. 1 to 4 there is illustrated an electrical intruder detection circuit according to the invention indicated generally by the reference numeral 1 of the type which would normally be used in a security circuit for detecting a break-in and an attempted break-in to a building or the like. The circuit 1 comprises a plurality of sensor units 2, 3 and 4 which are connected by a two wire circuit comprising an A wire and a B wire. The A and B wires form a loop circuit 6 which extends between a pair of input terminals 8 and 9. A main control

circuit 10, which is illustrated in block representation in Fig. 1, monitors the loop circuit 6 across the input terminals 8 and 9 for determining if an alarm condition exists in the loop circuit 6. There are three sensor units 2, three sensor units 3 and one sensor unit 4. All the sensor units 2, 3 and 4 comprise a housing 11 which is illustrated in block representation by broken lines in Fig. 1 and by full lines in Figs. 2 to 4.

Each housing 11 includes a tamper indicating means which is provided by a bi-stable bi-state device, namely, a normally closed bi-state tamper indicating switch 12 for indicating tampering with the housing 11. The tamper indicating switches 12 may be considered to form one zone of the security circuit 1. Such tamper indicating switches will be well known to those skilled in the art.

The sensor units 2 each comprise a bi-stable bi-state device, namely, a bi-state reed switch 14 which is held in a normal closed state by an adjacent magnet. Such reed switches for use in sensor units will be well known to those skilled in the art, they are typically used for mounting on a door or window frame or the like for detecting opening and/or closing of the door or window on which a corresponding magnet (not shown) is

mounted. The reed switches 14 of the sensor units 2 may be considered as forming another zone of the security circuit 1.

Each sensor unit 3 comprises a normally closed mono-stable bi-state device, namely, an inertia switch 15. Such inertia switches will be well known to those skilled in the art. They are typically used for mounting on a door or window frame or the like for detecting vibrations or a shock induced in the door or window caused by an attempt to break in or break down the door or window. The inertia switches 15 of the sensor units 3 may be considered as forming another zone of the security circuit 1.

The sensor unit 4 comprises a normally closed bi-stable bi-state device, namely, a bi-state switch 16 which is button operated, and is normally referred to as a panic switch for enabling activation by an individual in the event of an emergency or the existence of an alarm condition. The panic switch 16 may be considered as forming a further zone in the security circuit 1.

The tamper switches 12, the reed switches 14, the inertia switches 15 and the panic switch 16 are connected in series in the loop circuit 6. The A and B wires which extend from the respective input terminals

8 and 9 terminate in a main impedance element, namely, an end of line resistor R1 which completes the loop circuit 6 between the input terminals 8 and 9. The end of line resistor R1 is provided for enabling detection of a short circuit between the A and B wires, as will be described below. The tamper switches 12 are connected in series by the B wire which forms the return leg of the loop circuit 6, while the reed switches 14, the inertia switches 15 and the panic switch 16 are connected in series by the A wire which forms the outward leg of the loop circuit 6.

Some of the bi-stable devices, in this case, the reed switches 14 and the panic switch 16 each have an associated impedance element, namely, an associated resistor which is connected in parallel with the corresponding switch. The reed switches 14 each have an associated resistor R2, and the resistance value of the associated resistors R2 of the respective reed switches 14 of the sensor units 2 are identical, but different to the resistance value of the end of line resistor R1. The panic switch 16 has an associated resistor R3 associated with it, and the resistance value of the associated resistor R3 is significantly higher than the resistance value of the respective associated resistors R2, and is also higher than the sum of the resistance values of the associated

resistors R2. The resistance value of the resistor R1 is higher than that of the resistor R3. The provision of the resistors R1, R2 and R3 enables the control circuit 10 to determine which type of bi-state device 12, 14, 15 and 16 of sensor unit 4, 5 and 6 has changed state. The provision of the end of line resistor R1 enables the control circuit 10 to detect a short circuit across the A and B wires should an attempt be made to isolate part of the loop circuit 6 from the input terminals 8 and 9. This is all achieved as will be described below by the two wire system whereby switches 12, 14, 15 and 16 of the sensor units 2, 3 and 4 are all connected in series by the two A and B wires.

When the bi-state switches 12, 14, 15 and 16 are all in the closed state as illustrated in Fig. 1, the loop circuit 6 has a total impedance across the input terminals 8 and 9 of a predetermined value which is equal to the resistance value of the end of line resistor R1. When any one or more of the tamper switches 12 open, the total impedance of the loop circuit 6 across the input terminals 8 and 9 goes to infinity. In other words, the loop circuit 6 between the input terminals 8 and 9 is open circuit. Should one of the reed switches 14 open, when all the other switches 12, 15 and 16 are closed, the impedance of the loop circuit 6 increases from the resistance value of

the resistor R1 to the sum of the resistance values of the resistor R1 and the resistor R2 associated with the open reed switch 14. Should two or more of the reed switches 14 open, then the impedance of the loop circuit 6 is further increased by the sum of the resistance values of the resistors R2 associated with each of the reed switches 14 which open. When the panic switch 16 opens and all the other switches 12, 14 and 15 are closed, the impedance of the loop circuit 6 increases from the resistance value of the resistor R1 to the sum of the resistance values of the resistors R1 and R3. In this embodiment of the invention the values of the resistors R1, R2 and R3 are chosen so that no matter what combination of resistors R1, R2 and R3 are added into the impedance of the loop circuit 6, the impedance of the loop circuit 6 is always a unique identifiable value. Thus, by monitoring the impedance of the loop circuit 6 across the input terminals 8 and 9, a determination can readily easily be made as to which type of switch or switches 12, 14 or 16 have changed state, and additionally, the number of switches which have changed state may also be determined. Additionally, by monitoring the mark space ratio of a signal applied to the input terminals 8 and 9, a determination can readily be made as to whether an inertia switch 15 has gone into a vibration mode.

The main control circuit 10 monitors the loop circuit 6. The control circuit 10 applies a DC voltage of 12 volts to the loop circuit 6 across the input terminals 8 and 9, and monitors the current flowing through the loop circuit 6. A comparing means which is not shown but is implemented in the main control circuit 10 in hardware and software compares the current flowing in the loop circuit 6 with reference current values, for in turn determining the impedance in the loop circuit 6 so that the type or types of switches 12, 14 or 16 which have opened may be determined. The comparing means also compares the mark space ratio of a graph of the current flowing through the loop circuit 6 with reference mark space ratios for determining if one or more of the inertia switches 15 has commenced to vibrate.

Referring now to Fig. 6 a graph illustrating some of the various current signals flowing through the loop circuit 6 on a voltage being applied across the input terminals 8 and 9 is shown. The X-axis of the graph represents time while the Y-axis represents current. The graph for time A illustrates the current flowing through the loop circuit 6 when normal conditions prevail, in other words when all the bi-state devices 12, 14, 15 and 16 are closed. When one of the reed switches 14 opens the associated resistor R2 is shunted

into the loop circuit 6, thereby reducing the current through the loop circuit 6, as is illustrated by the graph for time B. The current flowing through the loop circuit 6 remains in this condition for so long as the reed switch 14 of one of the sensor units 2 remains open. On the reed switch 14 closing the current flowing through the loop circuit 6 returns to normal. However, it should be noted that while the reed switch 14 is open electrical continuity is maintained through the loop circuit 6 between the input terminals 8 and 9 through the resistor R2, and thus, a change in state of any of the other bi-state devices 12, 14, 15 and 16 can be detected.

Should a second of the three reed switches 14 open while the first of the reed switches 14 is still open, a second resistor R2 is shunted into the loop circuit 6, thereby further reducing the current flowing through the loop circuit 6, see the graph for time C. A third reed switch 14 opening while the other two reed switches 14 are open will further reduce the current flowing through the loop circuit 6, and the current through the loop circuit 6 is illustrated by the graph for time D. On all three reed switches 14 closing, the current flowing through the loop circuit 6 returns to normal, see the portion of the graph for time E.

Should any of the inertia switches 15 be activated and commence vibrating, the graph of current flowing through the loop circuit 6 is as illustrated by the part of the graph for time F. Thus, by comparing the current flowing through the loop circuit 6 with a reference current and with a reference mark space ratio, an immediate identification of activation of an inertia switch 15 is made. On the inertia switch 15 returning to the normal closed state, the current flowing through the loop circuit 6 returns to normal, see the portion of the graph for time G.

Opening of the panic switch 16 shunts the resistor R3 into the loop circuit 6 thereby reducing the current flowing through the loop 6, see the graph for time H. Since the resistance value of the resistor R3 is greater than the sum of the three resistors R2, identification of the panic switch 16 having changed state can be made. Should the panic switch 16 be opened while one or more of the reed switches 14 are open the resistance value of the loop circuit 6 increases to the sum of the resistances of the resistor R1, the resistor R3 and the number of resistors R2 associated with open reed switches 14. Since this will be a unique value, the main control circuit 10 can determine that the panic switch 16 is in open state and that one or more reed switches 14 are in open state,

and the number of reed switches 14 which are in the open state.

Should an attempt be made to tamper with the housing 11 of any of the sensor units 2, 3 and 4, which causes the corresponding tamper switch 12 to open, the loop circuit 6 goes on open circuit for so long as the tamper switch 12 remains open. The current flowing through the loop circuit 6 drops to zero, thereby indicating that a tamper switch 12 is open, or either one of or both the A and B wires have been cut, see the graph for time J.

An attempt to short circuit the A and B wires can be detected since the resistance of the loop circuit 6 is significantly reduced due to the fact that the end of line resistor R1 is shorted out, and the current increases as indicated by the portion of the graph for time L. The value of the current flowing through the loop circuit 6 in the event of a short circuit depends on where the short circuit occurs and the state of the bi-state devices 12, 14, 15 and 16 between the input terminals 8 and 9 and the location of the short circuit.

Thus, by the main control circuit 10 monitoring the value of the current signal flowing through the loop

circuit 6 and the mark space ratio of the current signal, a change in state of any of the bi-state devices in the loop circuit 6, and the particular type of bi-state device, the state of which has changed can readily be determined as well as the number of bi-state devices which have changed state.

Additionally, the main control circuit 10 can inhibit certain types of bi-state devices of the sensor units 2, 3 and 4. For example, should it be desired that only changes of state of inertia switches 15 should activate an alarm, the main control circuit 10 is programmed to ignore any changes of state other than a change of state which would provide a signal similar to that which would be expected if an inertia switch 15 changed state, namely, a signal similar to that in the portion of the graph for time F. Likewise, should it be desired to inhibit all switches with the exception of reed switches 14 and the panic switch 16, the main control circuit 15 is programmed to ignore all signals with the exception of those which would be produced by either one or more of the reed switches 14 and/or the panic switch 16 changing state.

It will also be appreciated that should an inertia switch 15 change state while either one or more of the reed switches 14 is open and/or the panic switch 16 is

open, the control circuit 10 will still be able to identify the types of switches which have changed state, since the signal produced by an inertia switch 15 changing state will merely cause the current flowing in the loop circuit 6 to oscillate between the relevant current value and zero at the frequency of vibration of the inertia switch 15.

Referring now to Fig. 5 there is illustrated a sensor unit 20 one or more of which may also be connected into the loop circuit 6. The sensor unit 20 comprises a tamper switch 12, a reed switch 14 and an inertia switch 15. A resistor R2 of similar value to the resistor R2 connected across the reed switch 14 of the sensor units 2 is connected across the reed switch 14 of the sensor unit 20. The reed switch 14 and the inertia switch 15 are connected in series, and when the sensor unit 20 is connected into the loop circuit 6 both are connected in series in the A wire. The tamper switch 12 in the sensor unit 20 is connected in series with other tamper switches in the B wire.

Referring now to Fig. 7 there is illustrated an electrical security intruder detection circuit according to another embodiment of the invention indicated generally by the reference numeral 30 for detecting a break-in or an attempted break-in to a

building or the like. The security circuit is substantially similar to the circuit 1, and similar components are identified by the same reference numerals. The main difference between the circuit 30 and the circuit 1 is that five sensor units 2, each of which comprises a magnetic reed switch 14 and a tamper switch 12, are provided. Additionally, in this embodiment of the invention the tamper indicating switches 12 are connected in series with the other bi-state devices on the A leg of the loop circuit 6. Furthermore, a sensor unit 2*a* with a reed switch 14 and a tamper switch 12 is provided for use in connection with a door of the building which is the main entry-exit door. Thus, the reed switch 14 of the entry-exit sensor unit 2*a* must be identifiable as a different device to the reed switches 14 of the sensor units 2. In other words, the reed switch 14 of the entry-exit sensor unit 2*a* may be considered to form a further different zone. This is necessary since the entry-exit door, and in turn, the reed switch 14 of the entry-exit sensor unit 2*a* must be allowed to remain open for a predetermined time period after the main control circuit 10 has been set by a person preparing to leave the building, or on a person entering the building without activating an alarm. In order that a change in state of the reed switch 14 of the entry-exit sensor unit 2*a* can be identified, a second resistor R2 of

resistance value identical to the other resistors R2 is connected in parallel with the reed switch 14, thus reducing the value of resistance across the reed switch 14 of the entry-exit sensor unit 2*a* to ½ R2. Accordingly, a change of state of the reed switch 14 of the entry-exit sensor unit 2*a* can readily easily be identified by the control circuit 10 irrespective of the state of the other bi-state switches 14, 15 and 16. Needless to say, if two or more entry-exit sensor units 2*a* were required in the loop circuit 6, these could readily easily be connected into the loop circuit 6 and would each be provided with associated resistors. The resistance values of associated resistors of the entry-exit sensor units 2*a* would be identical to each other. However, if two or more entry-exit sensor units 2*a* were required, it would not be feasible to provide the reed switch 14 of each entry-exit sensor unit 2*a* with an associated resistor of value ½ R2, since, if the reed switches of the two entry-exit sensor units 2*a* were open simultaneously, the resistance value of the loop circuit 6 would be similar to the resistance value of the loop circuit 6, if one of the reed switches 14 of the sensor units 2 were open. Thus, the value of the resistance of the associated resistors of the reed switches 14 of a number of entry-exit sensor units 2 would be selected so that if one or more of the reed switches 14 of the entry-exit sensor units 2*a* were

open, the main control circuit 10 could identify this fact.

It is envisaged in practice that the sensor units 2 and 2*a* will be supplied with one resistor R2 connected in parallel with the reed switch 14. In this way, an installer could readily easily convert a sensor unit 2 to an entry-exit sensor unit 2*a* by connecting a second resistor R2 in parallel with the reed switch 14. That is, of course, where only one entry-exit sensor unit 2*a* is required in the circuit 30.

The advantages of the invention are many. By virtue of the fact that the type of sensor unit which has changed state can readily easily be identified by the main control circuit, while at the same time all the bi-state devices of the sensor units are connected in series on a loop circuit, the wiring of the circuit is considerably simpler than the wiring of such security circuits known heretofore. Additionally, it is only necessary to provide a main control circuit with a single monitoring zone.

While the impedance elements have been described as being resistors, it will be appreciated that other suitable impedance elements, for example, capacitors, inductance elements and the like may be used. Such

impedance elements will be connected appropriately relative to the bi-state device with which they are associated.

CLAIMS

1. An electrical circuit comprising a plurality of bi-state devices, each having a closed circuit state and an open circuit state, the bi-state devices being connected in series in a loop extending between two input terminals, at least one of the bi-state devices being a mono-stable device of the type hereinbefore defined, and a plurality of the bi-state devices being bi-stable devices of the type hereinbefore defined, there being provided at least one of each of N types of bi-stable devices, where N is an integer greater than zero, each of the bi-stable devices of at least N-1 types having an associated impedance element, the associated impedance elements being arranged with their corresponding bi-stable devices so that irrespective of the state of the bi-stable devices which include an associated impedance element, electrical continuity is maintained through the loop while the bi-stable devices without an associated impedance element and the mono-stable devices are in a closed circuit state, the associated impedance elements of the bi-stable devices which are of the same type each having the same impedance value, and the impedance value of the associated impedance elements of bi-stable devices of different types being different, so that the loop circuit has a predetermined value of impedance across the input terminals when all the said bi-state devices

are in a normal state, and a value of impedance different from the said predetermined value when one of the bi-state devices is caused to change state for enabling the type of bi-state device which has changed state to be identified.

2. An electrical circuit as claimed in Claim 1 in which each associated impedance element is connected in parallel with its corresponding bi-stable device.

3. An electrical circuit as claimed in Claim 1 or 2 in which each associated impedance element comprises a resistor.

4. An electrical circuit as claimed in any preceding claim in which the values of the associated impedance elements are selected so that when more than one bi-state device changes state the type or types of bi-state devices which have changed state can be identified from the impedance value of the loop circuit.

5. An electrical circuit as claimed in any preceding claim in which a main impedance element is connected in the loop circuit in series with the bi-state devices so that should the main impedance element be shunted out of the loop circuit by short circuiting the loop

circuit by connecting any portion of the loop between one of the input terminals and the main impedance element with any portion of the loop between the other input terminal and the main impedance element, the impedance of the loop circuit across the input terminals changes for enabling detection of the short circuit.

6. An electrical circuit as claimed in Claim 5 in which the loop circuit comprises two legs, namely, an outgoing leg and a return leg, one end of the outgoing leg being connected to one of the input terminals, and one end of the return leg being connected to the other of the input terminals, the other ends of the respective outgoing and return legs being connected to the main impedance element.

7. An electrical circuit as claimed in Claim 6 in which the bi-stable devices with the associated impedance elements and the mono-stable devices are connected in series in one of the said outgoing and return legs, and the bi-stable devices without an associated impedance element are connected in series in the other of the outgoing and return legs of the loop circuit.

8. An electrical circuit as claimed in any of claims

5 to 7 in which the main impedance element is a resistor.

9. An electrical circuit as claimed in any preceding claim in which each bi-stable device comprises a switch.

10. An electrical circuit as claimed in any preceding claim in which each bi-stable device of one type comprises a magnetic reed switch.

11. An electrical circuit as claimed in any preceding claim in which each bi-stable device of one type comprises a button operated panic switch.

12. An electrical circuit as claimed in Claim 10 or 11 in which each magnetic reed switch is provided with one of the associated impedance elements, and each button operated panic switch is provided with one of the associated impedance elements.

13. An electrical circuit as claimed in any preceding claim in which each bi-stable device of one type comprises a tamper indicating switch associated with a housing of a sensor unit which comprises at least one of two or more different bi-state devices.

14. An electrical circuit as claimed in any preceding claim in which at least one of the mono-stable devices comprises a vibration sensing device.

15. An electrical circuit as claimed in any preceding claim in which at least one of the mono-stable devices comprises a shock sensing device.

16. An electrical circuit as claimed in any preceding claim in which at least one of the mono-stable devices comprises an inertia switch.

17. An electrical circuit as claimed in any preceding claim in which each mono-stable device is stable in the closed circuit state.

18. An electrical circuit as claimed in any preceding claim in which the electrical circuit further comprises a main control circuit connected to the input terminals of the loop circuit for monitoring the impedance of the loop circuit across the two input terminals for determining if and which type of bi-state device has changed state.

19. An electrical circuit as claimed in Claim 18 in which the main control circuit comprises a means for comparing the impedance value of the loop circuit with

a plurality of reference impedance values for determining the type or types of bi-state devices which have changed state.

20. An electrical circuit as claimed in Claim 18 or 19 in which the main control circuit comprises a means for applying a voltage across the input terminals of the loop circuit, and the comparing means comprises a means for monitoring the current flowing through the loop circuit for determining the impedance value of the loop circuit.

21. An electrical circuit as claimed in any of Claims 18 to 20 in which the comparing means comprises a means for detecting the mark space ratio of the current flowing through the loop circuit for determining the mark space ratio of a graph of the current for determining the frequency of change of the current for determining the type of bi-state device which has changed state.

22. An electrical circuit as claimed in Claim 21 in which the comparing means compares the mark space ratio of the current signal flowing through the loop circuit with a reference mark space ratio for determining if a mono-stable device has changed state.

23. An electrical circuit as claimed in any preceding claim in which the electrical circuit is a security intruder detection circuit.

24. An electrical circuit substantially as described herein with reference to and as illustrated in the accompanying drawings.

25. A sensor unit for use in the electrical circuit as claimed in any preceding claim, the sensor unit comprising a housing, and at least two bi-state devices located in the housing, and arranged for connecting into the loop circuit in series, one of the bi-state devices being a tamper indicating means for indicating tampering with the housing, and the other of the bi-state devices being a bi-stable device, and an associated impedance element being associated with the bi-stable device.

26. A sensor unit as claimed in Claim 25 in which the bi-stable device is a magnetic reed switch.

27. A sensor unit as claimed in Claim 25 or 26 in which the tamper indicating means is a bi-stable switch, the state of the bi-stable switch being responsive to tampering with the housing.

28. A sensor unit as claimed in Claim 27 in which both of the bi-stable devices are normally closed.

29. A sensor unit as claimed in any of Claims 25 to 28 in which the associated impedance element is a resistor.

30. A sensor unit for use in the electrical circuit as claimed in any of Claims 1 to 24, the sensor unit being substantially as described herein with reference to and as illustrated in the accompanying drawings.

31. A kit of parts for forming the electrical circuit as claimed in any of Claims 1 to 24.

The Patent Office

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Application No:	GB 9601625.8	**Examiner:**	Stephen Brown
Claims searched:	1-24	**Date of search:**	8 March 1996

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): G4N: NAB, NCSE, NEPS, NEPD, NEL, NDAL, G4H: NHA

Int Cl (Ed.6): G08B - 13/00, 19/00, 23/00

Other: Online WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB 2 145 863 A	(Pittway) see especially page 1, lines 35-45.	1 at least
Y	GB 2 111 273 A	(Gateway)	1 at least
Y	GB 2 101 781 A	(United Gas)	1 at least
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